Integrating Multi-Platform Precipitation Observations for an Atmospheric Column Data Product

Stephanie M. Wingo[1], David Marks[2], David Wolff[3], and Walt Petersen[4]
[1]SSAI at NASA WFF (stephanie.m.wingo@nasa.gov), [2]SSAI at NASA WFF, [3]NASA WFF, [4]NASA MSFC

Motivation

- The GPM goal of advancing water and energy cycle understanding requires space- and ground-based precipitation observations across the globe.
- GPM's Ground-Validation (GV) effort seeks to combine these measurements to provide direct & physical comparisons as well as an assessment of assumptions used in satellite retrieval algorithms.

NASA Wallops' Precipitation Research Facility

- Maintains a full suite of precipitation instruments in routine operation across the MD/VA Eastern Shore
- Several WFF PRF platforms were also deployed to support GPM GV Field Campaigns
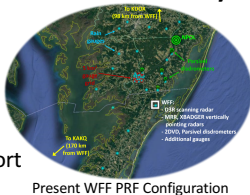
Present WFF PRF Configuration

Locations of WFF PRF-provided instruments deployed in OLYMPEX

extensive obs. in varied wx & topo

- GPM GV network currently produces a matched-beam product for ground- vs. space-based GPM DPR radar studies (Schwaller and Morris 2011)
- Column data product we generate: incorporates ground-based sensor suite to enable comparisons, document profile variability on pixel/sub-pixel scales

Arrays of Data Platforms

Scanning Radars

NASA S-band Polarimetric Radar (NPOL) 10.6 cm/2.8 GHz
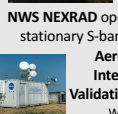
Dual-pol. Dual-freq. Doppler Radar (D3R) Ka-/Ku-band 0.8/2.2 cm 35.5/13.9 GHz

NWS NEXRAD operational network of stationary S-band, dual-pol radars

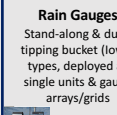**Aerosol Cloud Humidity Interactions Exploring & Validating Enterprise (ACHIEVE)** W-/K-band, 95/24 GHz

Profiling Radars

Micro Rain Radar (MRR) K-band (24GHz) FM-CW Reflectivity/velocity and LWC, DSD profiles (WFF PRF: 4 MRR units)

X-band Atmospheric Doppler Ground Radar (X-BADGER) 3 cm/9.6 GHz

Point Observations

Rain Gauges Stand-along & dual-tipping bucket (Iowa) types, deployed as single units & gauge arrays/grids

Parsivel Disdrometers (autonomous units) APU sites collocated gauge and/or disdrometer

Pluvio Precipitation Gauges electronic weighing instruments for rain & snow

2D Video Disdrometers (2DVD) WFF PRF has 6 units, sites collocated with other disdrometers

GPM Core Observatory

GPM Microwave Imager (GMI) 13 channel radiometer (10-183 GHz)

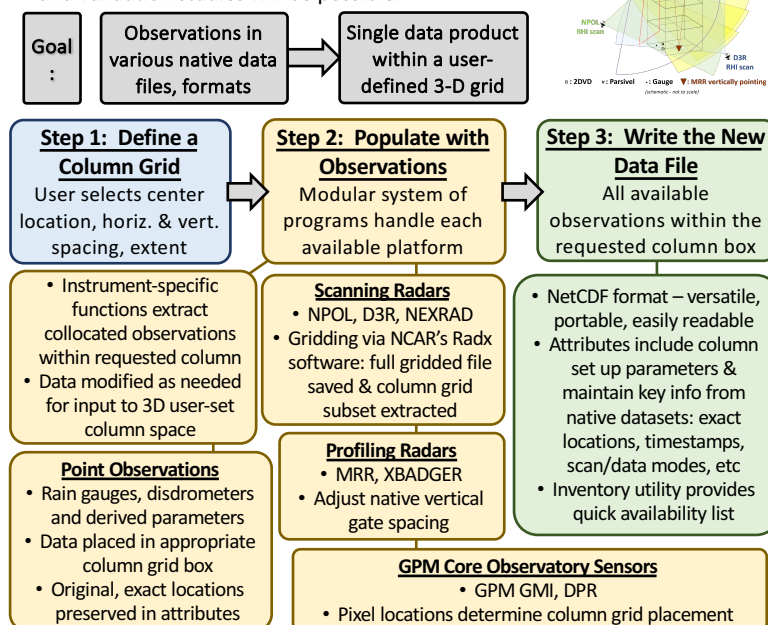**Dual-frequency Precipitation Radar (DPR)** Ka/Ku-band (35.5/13.6 GHz)

Framework to Synthesize Observations

Physical validation work relies on targeted observations: (1) rain gauges disdrometers, (2) ground-based radars, (3) in situ and (4) high altitude aircraft-mounted sensors.
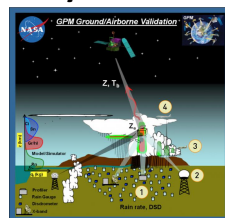
Measurements are analyzed to improve microphysical precipitation process understanding, assess validity & representativeness of retrieval algorithm assumptions

- To better leverage these datasets, we are developing a tool to synthesize observations from several sensors into a single, atmospheric column data product, combining coincident measurements to "build the column."
- With integrated multi-platform measurements in a consistent framework, efficient new comparison, process, and validation studies will be possible.

Goal: Observations in various native data files, formats → Single data product within a user-defined 3-D grid

Step 1: Define a Column Grid
User selects center location, horiz. & vert. spacing, extent
- Instrument-specific functions extract collocated observations within requested column
- Data modified as needed for input to 3D user-set column space

Point Observations
- Rain gauges, disdrometers and derived parameters
- Data placed in appropriate column grid box
- Original, exact locations preserved in attributes

Step 2: Populate with Observations
Modular system of programs handle each available platform

Scanning Radars
- NPOL, D3R, NEXRAD
- Gridding via NCAR's Radx software: full gridded file saved & column grid subset extracted

Profiling Radars
- MRR, XBADGER
- Adjust native vertical gate spacing

GPM Core Observatory Sensors
- GPM GMI, DPR
- Pixel locations determine column grid placement

Step 3: Write the New Data File
All available observations within the requested column box
- NetCDF format – versatile, portable, easily readable
- Attributes include column set up parameters & maintain key info from native datasets: exact locations, timestamps, scan/data modes, etc
- Inventory utility provides quick availability list

Currently Supported Data Fields:

NPOL & NEXRAD:
- GPM GC DP QC (Marks et al. 2011, Pippit et al. 2013)
- Z, V_r, SW, Z_{dr}, ρ_{hv}, Φ_{dp}, K_{dp}
- Rain rates, D_0, D_M, N_w

D3R:
- Ka-band: Z, V_r, SW, Z_{dr}, ρ_{hv}, Φ_{dp}
- Ku-band: Z, V_r, SW, Z_{dr}, ρ_{hv}, Φ_{dp}, K_{dp}

MRR (profiles):
- Z, Vr (W = w + V_t)
- DSD parameters: D_0, N(D) in 64 size bins
- rain rate, PIA, LWC

2A-GPROF GMI:
- Sfc precip, TPW, liq. & convec. fracts.
- Ice, cloud, mix-phase, rain water paths

APU (Parsivel disdrometers):
- Total # of drops, concentration, LWC, rain rate, Dmax, DM
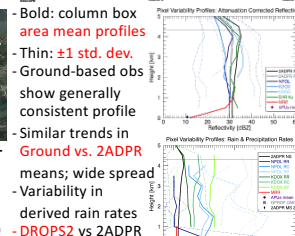- Derived radar attenuation & reflectivity (pure Rayleigh, S- through W-band)

2A-DPR:
- Ka/Ku Z, atten/PIA, BB params
- Precip. rate, phase, type

Exploring Applications Avenues
28 June 2016 - GPM Core Overpasses the WFF PRF

Widespread, convective & stratiform rain

Placement of column grid over WFF base (5 x 5 x 5 km, 500 m spacing)
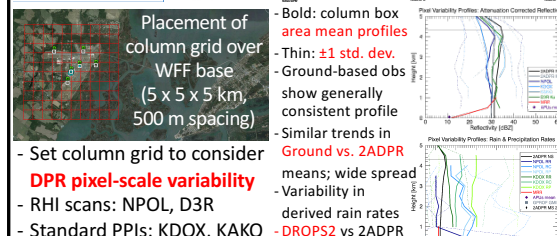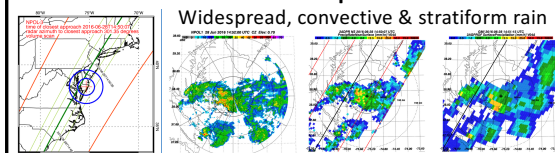
- Set column grid to consider DPR pixel-scale variability
- RHI scans: NPOL, D3R
- Standard PPIs: KDOX, KAKQ

- Bold: column box area mean profiles
- Thin: ±1 std. dev.
- Ground-based obs show generally consistent profile
- Similar trends in means; wide spread Ground vs. 2ADPR
- Variability in derived rain rates
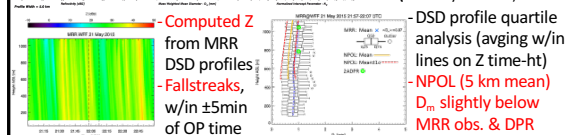- DROPS2 vs 2ADPR

Ground Radar-based DSD Profile Analysis (courtesy D. Wolff)
- Vertical profiles from NPOL RHIs (vertical lines = avging region)
- 5 km aerial mean vertical profiles of Z, radar-derived DSD params
- Black: mean
- Blue: ±1 std. dev.
- Red: coef. of var (σ/μ)
- DSDs valid only below freezing level (horiz. lines)-liquid assumption

Another GPM OP at WFF: 21 May 2015

MRR DSD profile Obs. (courtesy P. Gatlin)
- DSD profile quartile analysis (avging w/in lines on Z time-ht)
- Computed Z from MRR DSD profiles
- Fallstreaks, w/in ±5min of OP time
- NPOL (5 km mean) D_m slightly below MRR obs. & DPR

Continuing Work
- Adding support for additional platforms: L1C GMI T_{BS}, 2AKA, 2AKU, 2DVD & Pluvio disdrometers, XBADGER profiling radar, additional rain gauges, etc…
- Showing framework's utility: new science, including supporting retrieval algorithm assumption assessments
- Extending to comparisons with in situ aircraft-based microphysics observations from GPM GV campaigns
- Long-term: can extend the flexible, modular system to allow others to incorporate their choice of extra/future platforms

We would like to acknowledge contributions from P. Gatlin (MRR profiles), A. Tokay (APU data processing), and M. Wingo (WFF PRF platform locations in OLYMPEX), as well as M. Schwaller of the GPM program for funding this project.